

Ecosystem-based Adaptation to Climate Change: Experience from Smallholder Floodplain Forest Management

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Abstract

Ecosystem-based Adaptation (EbA) is a strategy to use ecosystem services to help farmers'/communities to adapt to negative effects of climate change. This strategy is appropriate for smallholders to strengthen their livelihood security, diversify earning streams by taking advantage of their traditional knowledge. Therefore, the present study was undertaken to analyze how ecologically-based management system of floodplain *Barringtonia* forest helps the traditional communities to sustain their livelihood while managing the forest under changing climate. *Barringtonia acutangula* constitute floodplain forest ecosystem in Chatla wetland of Barak Valley, Assam. Fishery management for commercial fish production is the primary vocation of the floodplain communities. The species is managed for sprout production (sprout diameter >10cm and length >150cm, tree diameter > 20 cm), the latter is used extensively in fish farming to protect fishes from predator, poaching and theft, besides its commercial utility. Smallholder's forested *Barringtonia* zone ranges in size from 0.03 to 0.26 ha with mean stand density of 1293 trees ha⁻¹. Study revealed a unique ecologically compatible branch cutting technique which has been developed by the farmers' to facilitate high branch production from the limited number of trees that farmers' own. Such traditional technique sustainably utilizes the forest ecosystem and provide both on and off site ecosystem services. Therefore, ecologically based management practices can also contribute to climate change mitigation by reducing emissions from ecosystem loss and degradation, and enhancing carbon sequestration.

Keywords

Sprout Production; Climate Change Mitigation; Floodplain Forest Management

Introduction

Ecosystem- based Adaptation (EbA) is an approach to help smallholder farmer to adapt to climate change (UNFCCC 2013) through the use of biodiversity and ecosystem services or a part of an overall adaptation strategy (SCBD 2009). The EbA approaches harness the capacity of nature to buffer human communities against the adverse impacts of climate change and include the potential for natural infrastructure to provide disaster risk reduction, food security, sustainable water management and livelihood diversification (Jones et al. 2012). Smallholder farmers represent 85% of the world's farms (Nagayets 2005), most small areas of land are cultivated by family labour and depend on their farms as their main source of food security and income generation (Cornish 1998). Due to their significant contribution to social, economic and environmental consequences globally, smallholder managed ecosystems have an important role in climate change adaptation and mitigation. The floodplain areas remain among the most vulnerable ecosystem to climate change (Gopal and Chouhan 2006), exacerbated by rainfall reduction, increased variability, temperature and evaporation (Junk et al. 2013). A number of contributions have been made to relate statistical model with climate change adaptation and mitigation (Dawei et al. 2012, Dawei et al. 2013, Dawei et al. 2014), however, realizing the natural ecosystems which are dynamic systems driven by multiple feed forward and feedback actions among organisms and their biotic (abiotic) environment, and understanding of anthropogenic actions that can contribute to climate change adaptation and mitigation will certainly add value to the existing information on EbA. Therefore, understanding EbA of such system can improve

current management that maximizes mitigation measures. Natural floodplain systems are highly complex, diverse, and productive for ecological, social, and economic values (Tockner et al. 2008). Besides, they play an important role in sustaining regional biodiversity, improving water quality and enhancing capacity to produce trees and fish (Tockner et al. 2008). Floodplain tree ecosystems are important to management of water resources and dependent ecosystem (Junk et al. 2013). Therefore, any changes in floodplain tree ecosystem will affect the livelihood of people dependent on the floodplain, alongwith conservation goals, policies and programmes.

Chatla floodplain of Barak Valley, North East India represents 'Hijol' (*Barringtonia acutangula*) dominated forest ecosystem. *Barringtonia acutangula* is widely distributed throughout India, Southeast Asia, Australia and Africa (Nadkarni 1976) and has been managed by the floodplain people in India over a long period of time to meet their livelihood needs (Nath et al. 2010). In the seasonally flooded Chatla floodplain, the species is managed in a separate zone away from traditional homegarden forming a forested zone.

Zonation of traditional agroforestry systems based on function, location and species composition are frequent (Mendez et al. 2001; Kumar et al. 1994, Das and Das 2005). Such zones fulfil a number of needs of families, ranging from fodder, fuel-wood, timber, etc. (Das and Das 2005). Chatla floodplain is inhabited by a fishermen community called 'kaivartas' and the species is intricately related with their fish farming systems and therefore with their livelihood security. The branches of the trees are used in the fishery management. Fishing is the primary vocation of the floodplain people (Nath et al. 2010). Therefore, to ensure the sustainable production of branches to meet increasing demands under stressful environment of seasonal submergence, farmers have evolved ecologically based management system for *Barringtonia* trees. Keeping this in background, the research goal of the present study is to document such EbA approaches and to analyse these for climate change mitigation.

Research Methodology

Study Area

Present study was conducted in Chatla floodplain in Cachar district of Barak Valley, Assam. Chatla is the catchment of river Ghagra, the tributaries of river Barak. It lies between 90°45' North and 24°45' East. The topography of the area is low lying with numerous small hillocks where there are inhabited by the villagers. The geographical area of Chatla is ~10 km². The major ethnic group in the Chatla is the 'Kaivartas', a fisher community. In both rainy and winter seasons, the fisher community used to capture and trade fish. The rainy season extends from May to October and the winter season from November to March. Mean annual temperature and annual rainfall (2012-2014) range from 18- 30°C and 180 - 2500 mm respectively.

Methods

Two stages sampling strategy was adopted for analysing socio-economic status and density distribution of *Barringtonia* zone in floodplain of the study area. In the first stage of sampling, hundred households were selected through random sampling to analyse their socio-economic status. The information regarding socio-economic conditions and utilization and management of *B. acutangula* was gathered through the interaction with household owners and structured questionnaires (Chamber et al. 1989; Vogl et al. 2004) backed by field observations. Based on its size, the *Barringtonia* zone was categorized as small (<.05 ha), medium (>.05-0.1ha) and large (0.1-0.3ha). In the second stage of sampling, ten *Barringtonia* zone from each of the category was sampled for density distribution of trees. All trees were counted and measured for circumference at breast height (CBH).

Results and Discussion

Socio-economic Status

Socio-economic status of the fisherman community was determined on the basis of holding size of the *Barringtonia* zone, primary and secondary vocation, land use managed, education and annual earning. Holding size of *Barringtonia* zone ranges from 0.03 to 0.26 ha with an average of .07 ha. It was observed that majority of fishermen (60%) own smaller *Barringtonia* zone (<.05 ha). Medium (>.05-0.1) and larger (0.1-0.3) sized *Barringtonia* zone was owned by 20% of the fishermen in each category. Paddy land constitutes a major land use system (for 50% of the

fishermen) and farming is the primary vocation for the fishermen. In general, fishermen owing larger extent of paddy lands have larger holding size under fishery as well as *Barringtonia* zone. Members of poor families who own no or less paddy land had little or no education and possessed very small holding size under *Barringtonia* zone. Bamboo (*Bambusa* sp.) as the roofing material was observed for smaller holding size owner with agriculture and fishing as the primary vocation (Fig. 1).

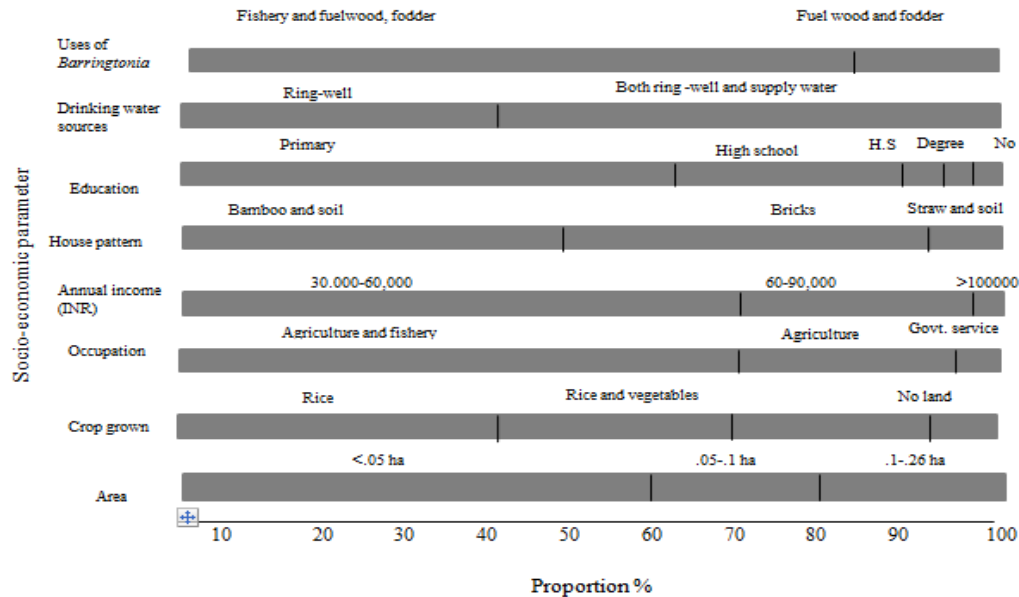


FIG. 1 SOCIO-ECONOMIC STATUS OF CHATLA FLOODPLAIN

Quantification of Stand Density

Analysis of the tree density revealed that the *Barringtonia* zone was stocked with 1293 trees ha⁻¹ and was positively related with holding size ($R^2=.56$). The data on size of *Barringtonia* zone and tree density presented in Table 1 indicate that differences are not statistically significant ($F=.122$, $p > .05$). A further analysis on the distribution of dominant girth size indicated that the contribution of 20-30 and 30-40 cm girth size was the highest across different *Barringtonia* zones (Fig. 2) suggesting the dominance of younger trees. Chatla floodplain (Fig. 3A) area lacks old trees of *Barringtonia* due to the historic anthropogenic perturbations (Gupta 2006).

TABLE 1: TREE DENSITY ACCORDING TO THE HOLDING SIZE OF *BARRINGTONIA* ZONE

Size of <i>Barringtonia</i> zone	Area (ha)	Tree density (ha ⁻¹)
Large	0.15 (0.1-0.3)	1422 (1000- 2623) ^a
Medium	0.06 (0.05-0.07)	1393 (516- 2577) ^a
Small	0.04 (0.03-0.05)	1248 (320- 2500) ^a

^a Tree density with respect to holding size is not significantly different at 5% level of significance



FIG. 2 DENSITY OF *BARRINGTONIA* TREES WITH RESPECT TO THEIR GIRTH SIZES



FIG. 3 (A) A PICTORIAL VIEW OF *BARRINGTONIA* FLOODPLAIN FOREST (B) CAPTURING FISH BY LOCAL PEOPLE (C) USE OF *BARRINGTONIA* BRANCHES IN THE FISHERY (D) MANAGEMENT OF *BARRINGTONIA* FOREST (E) DRYING BRANCHES AFTER COLLECTING FROM THE WATER BODY (F) COLLECTING OF DRIED LEAVES

Traditional Management System

Fish farming through the fishery management is the primary source of livelihood to fishermen community in both rainy and winter seasons in Chatla floodplain (Fig. 3B). To protect fish from predators, poaching and theft, branches of the *Barringtonia* tree are commonly used in fisheries as a part of the management (Fig. 3C). With the increase in demand of fish consumption, fish production through floodplain fishery management is increasing rapidly (World Fish Centre 2005). Therefore, to produce more branches from the same unit area of forest, farmers have developed an ecologically compatible management system. Farmers usually cut the branches/sprouts close to the trunk in every three years. The cut branches have diameter >10 cm and length >150 cm (tree diameter >20 cm) (Fig. 3D). Traditional cutting of branches resembles pollarding system as practiced in silvicultural practices. Sprouts are pollarded in the month of June-July that coincides with the rainy season. Adequate moisture in the

rainy season promotes sprout regeneration in the same harvesting year. Pollarding of *Barringtonia* tree is a forest management strategy to encourage the branch development by coppicing of the tree¹⁰. The tree is then allowed to re-grow after the initial cut that eventually results in a somewhat expanded top of the tree trunk with multiple new shoots growing from it. Therefore, the practice of pollarding maintains the supply of branches. Traditional utilization of sprouts involves, cutting of the sprouts and allowing for sun drying for 15-20 days. After sun drying and shedding of leaves, branches are kept submerged in the water. During the winter season when fisheries dry, the branches are collected again from the water and after drying, are reused as fuel wood (Fig. 3E). Diversity in the utilization of the branches of the species is a critical feature of the system. The rough surface of the branches helps the growth of algae on it and subsequently becomes an important source of fish food. Forest managers sell sprouts of *Barringtonia* once in every three years. Sprouts are sold to the farmers who do not own their personal *Barringtonia* forest in the same or in a distant floodplain. Forest managers prefer to harvest the older sprouts (> 3 yrs). Younger sprouts (< 3 yrs) are retained in the tree for subsequent new sprout production and to maintain a sustainable harvest cycle. On an average, an individual farmer sells ~ 300 sprouts per year and generates INR 4,000 annually. Dried leaves are collected by women and used as fuel for cooking purposes (Fig. 3F). This indicates that the farmer's ecological knowledge is largely practical in nature and is influenced by the interactive effects of ecological and socio-economic constraints. Besides, *Barringtonia* forest provides different types of services to the local inhabitants (Figure 4). Therefore, management of the species in floodplain can provide benefits on a local and national level through livelihood, economy and environmental security for the inhabitants of the floodplain area.

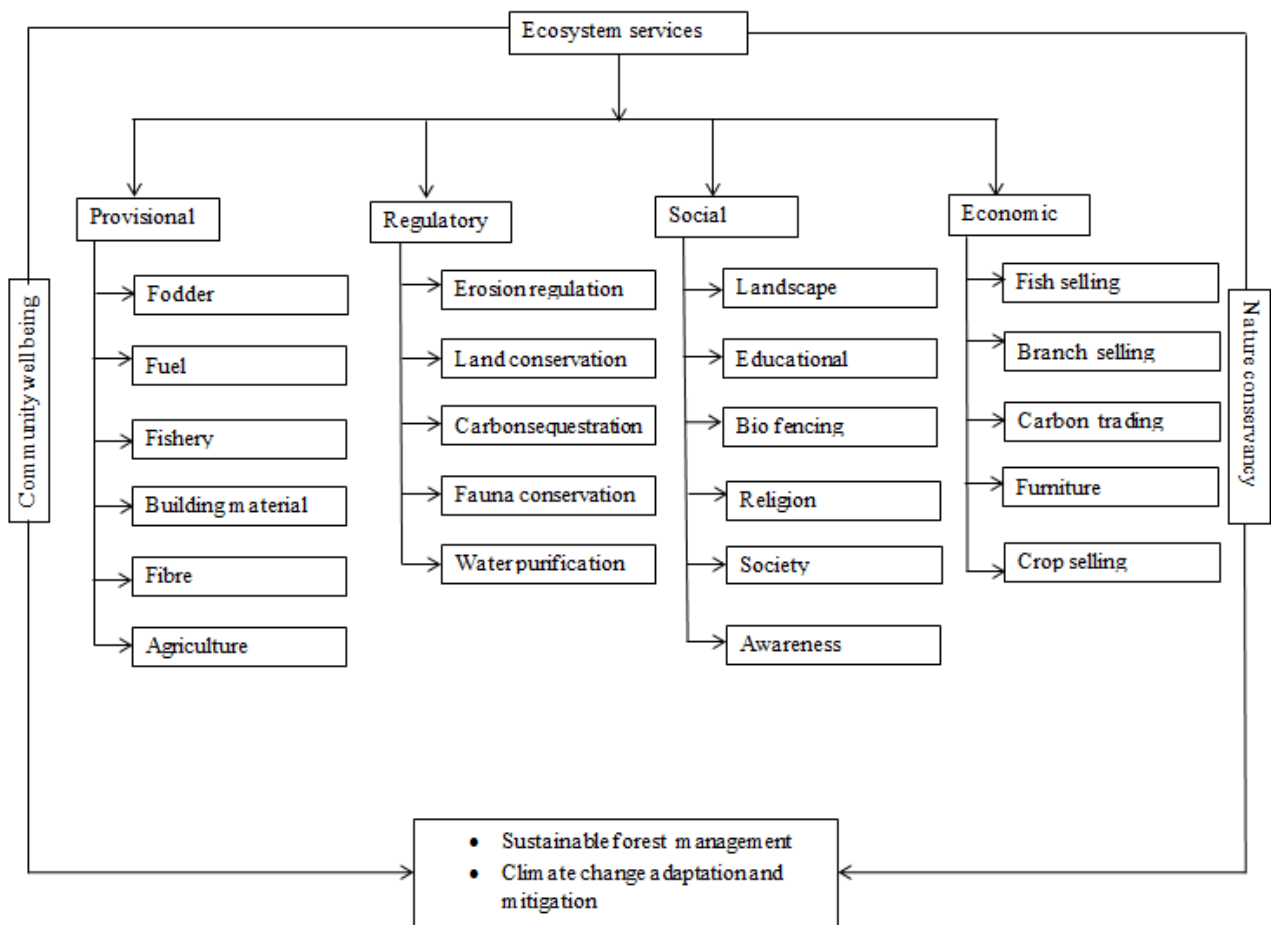


FIG. 4 ECOSYSTEM SERVICES PROVIDED BY FLOODPLAIN *BARRINGTONIA* FOREST

Conclusion

The approach of *Barringtonia* forest management to secure livelihood and to generate income also ensures the sustained provision of ecosystem services to help smallholder farmers adapt to climate change. Such EbA can further increase their food security, diversify and increase income streams, and maximize other ecosystem services for nature conservancy. Therefore, it is appropriate to take advantage of such traditional knowledge to develop the

innovative extension programme for smallholder farmers'. Further study is required to understand how such floodplain forest ecosystems can be promoted to safeguard vulnerable people against extremes of flood and drought.

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REFERENCES

- [1] Chamber, R., Pacey A., and Thrupp, L.A., eds. Farmer first: Farmer innovation and agricultural Reaserch, Intermediate Technology Publication, London U.K, 1989.
- [2] Cornish, G., Modern Irrigation Technologies for Smallholders in Developing Countries. Intermediate Technology Publications Ltd. (ITP), Wallingford, UK. 1998.
- [3] Das, T., and Das, A.K., Inventorying plant biodiversity in homegardens: A case study in Barak Valley, Assam, North East India. *Curr. Sci.*, 2005, 89, 155-163.
- [4] Dawei Hu, Rui Zhou, Yi Sun, Ling Tong, Ming Li, Houkai Zhang., Construction of closed integrative system for gases robust stabilization employing microalgae peculiarity and computer experiment. *Ecol. Eng.* 2012, 44, 78-87.
- [5] Dawei Hu, Houkai Zhang, Leyuan Li, Rui Zhou, Yi Sun., Mathematical modeling, design and optimization of conceptual configuration of soil-like substrate bioreactor based on system dynamics and digital simulation. *Ecol. Eng.* 2013, 51, 45-58.
- [6] Dawei Hu, Liang Li, Hui Liu, Yi Sun, Leyuan Li, Yuming Fu, Houkai Zhang., Design and control of rotating soil-like substrate plant-growing facility based on plant water requirement and computational fluid dynamics simulation, *Ecol. Eng.* 2014, 64, 269-275.
- [7] Gopal, B., and Chauhan M., Biodiversity and its conservation in the Sundarban mangrove ecosystem. *Aquat. Sci.*, 2006, 68, 338-354.
- [8] Gupta, A., Water availability, poverty and socio-economic crisis in the floodplains of Barak Valley, Assam, North East India, www.mpl.ird.fr/ur_004/projects/textes 2006.
- [9] Jones, H. P., Hole, D.G., and Zavaleta, E.S., Harnessing nature to help people adapt to climate change. *Nat. Clim. Chang.*, 2012, 2, 504-509.
- [10] Junk, W., An S., Finlayson, C. M., Gopal, B., Květ, J., Mitchell S., Mitsch W. and Robarts, R., Current state of knowledge regarding the world's wetlands and their future under global climate change: A synthesis. *Aquat. Sci.*, 2013, 75, 151-167. Retrieved from <http://dx.doi.org/10.1007/s00027-012-0278-z>.
- [11] Kumar, B.M., George, S.J., and Chinnamani S., Diversity, structure and standing stock of wood in the homegardens of Kerala in Peninsular India. *Agrofor. Syst.*, 1994, 25, 243-262.
- [12] Mendez, V.E., Lok, R., and Somarriba, E., Interdisciplinary analysis of homegardens in Nicaragua: Micro-zonation, plant use and socioeconomic importance. *Agrofor. Syst.*, 2001, 51, 85-96.
- [13] Nadkarni, K.M., *Materia Medica*, revised and enlarged by Nadkarni, A.K. Bombay Popular Prakashan 1976, 1: 1161.
- [14] Nagayets, O., Small farms: current status and key trends. *The Future of Small Farms: Proceedings of a Research Workshop*, IFPRI, Wye, UK, 2005, pp. 355-367.
- [15] Nath, A.J., Raut, A., and Bhattacharjee, P.P., Traditional use of *Barringtonia acutangula* (L.) Gaertn. in fish farming in Chatla floodplain of Cachar, Assam. *Indian J. Tradit. Know.*, 2010, 9, 544-546.
- [16] SCBD (Secretariat of the Convention on Biological Diversity), Connecting Biodiversity and Climate Change: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. CBD, UNEP, Montreal, Canada, 2009.
- [17] Tockner, K., Bunn, S., Gordon, C., Naiman, R.J., Quinn, G.P., and Stanford, J.A., Flood plains: critically threatened ecosystems. Polunin, N.V.C. (eds), In *Aquatic Ecosystems*, Cambridge: Cambridge University Press, 2008.

- [18] UNFCCC (United Nations Framework Convention on Climate Change), Report of the subsidiary body for scientific and technological advice on its thirty-eighth session, held in Bonn from 3 to 14 June 2013. UN, <http://unfccc.int/bodies/body/6399/php/view/reports.php>. 2013.
- [19] Vogl, C.R., Vogl-Lukasser B., and Puri R.K., Tools and methods for data collection in ethnobotanical studies of homegarden. *Field. Method.*, 2004, 16, 285-306.
- [20] World Fish Center, The Strategies and options for increasing and sustaining fisheries and aquaculture production to benefit poorer households in Asia, ADB-RETA 5945: project completion report (main report) Penang, Malaysia: The World Fish Center, 2005.